Alberta Geological Survey

Rock Chips

Spring 2010

Alberta Mineral and Diamond Potential Summary

Information Series report 137 is a compilation map to make industry, government and Albertans aware of Alberta's metallic mineral and diamond potential. The map displays the locations of more than 4000 deposits, occurrences and samples based on about 50 industry (mineral assessment) and government sources (including previous mineral potential compilations).

The map also highlights deposits and mineral occurrences that currently have an elevated level of exploration interest. Examples of these include the Clear Hills iron deposits, diamondiferous kimberlites in the Buffalo Head Hills, polymetallic black shale in the Birch Mountains, Burmis magnetite, Prairie Evaporite Formation potash, Athabasca uranium and Swan Hills lithium, all of which occur in rural or remote areas of Alberta.

Industry should note the variety of mineral resources in Alberta, including diamonds, base and precious metals, uranium, potash and lithium. For government, the map can educate land-use framework and Alberta Land Stewardship Act leaders on the potential commodities for the diversification of Alberta's resource base.

Recognition and sustainable management of Alberta's mineral resources should be considered to meet the current and future needs of Albertans. ❖

Scaled-down version of INF 137, Metallic Mineral and Diamond Potential of Alberta Summary. The map represents data from about 50 industry (mineral assessment) and government sources.

ERCB Energy Resources Conservation Board | AGS Alberta Geological Survey

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Story Contact Information

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Documenting Seismicity in Alberta
Virginia Stern (780) 422-7945

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Documenting Seismicity in Alberta

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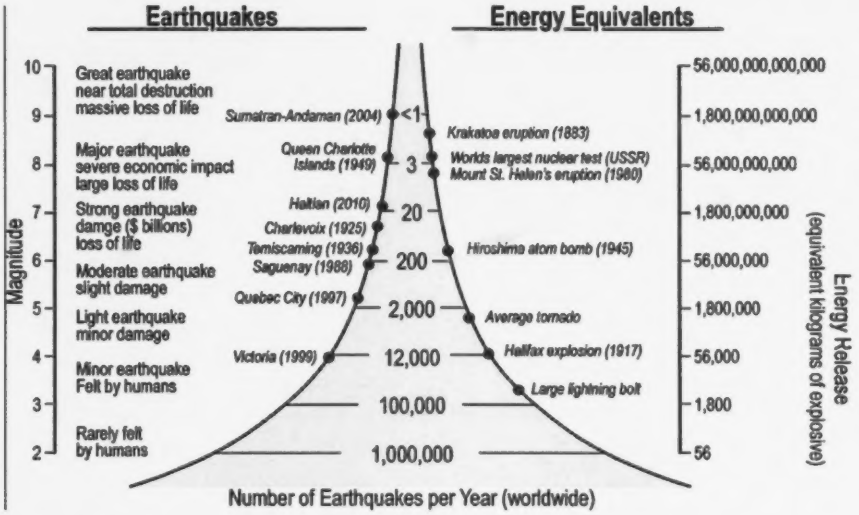

Diagram modified from Earthquakes Canada.

Two examples of large, destructive earthquakes in the past decade:

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Earthquake classifications, magnitudes and their possible effects

Class	Effects	Magnitude (M)
Great	Destructive	8 or greater
Major	Serious damage	7 to 7.9
Strong	Damage in populated areas	6 to 6.9
Moderate	Slight damage to buildings and structures	5 to 5.9
Light	Felt, but only minor damage	4 to 4.9
Minor	Felt, usually no damage	3 to 3.9
Micro	Not usually felt below 2.5	Less than 3

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The reason for the apparent increase in seismic activity after the mid- to late-1970s is unclear. The number and distribution of stations did not change appreciably from 1966 to the 1990s. In the 1990s, the federal government replaced their seismographs with digital equipment. These improvements to the network of seismic stations have lowered the detection limit for small to micro-earthquakes in southwestern Alberta.

Earthquakes Canada recorded about 819 earthquakes in Alberta between 1918 and 2009, compared with 13 in Saskatchewan during the same time. However, these numbers are small when compared with the more than 1200 earthquakes recorded in B.C. for 2007.

Most of Alberta's earthquakes are distributed evenly along the foothills and Rocky Mountains. These earthquakes occur within the thrust-fault systems associated with the ancient mountain-building processes that created the Rocky Mountains. There are also clusters of earthquakes detected east of the Rocky Mountain deformation belt. The larger clusters are near Brazeau River, Turner Valley and south of Rocky Mountain House.

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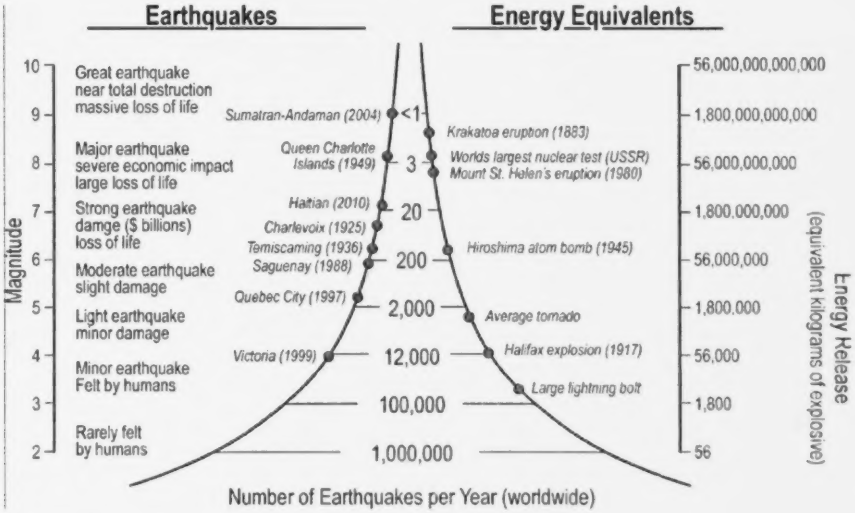

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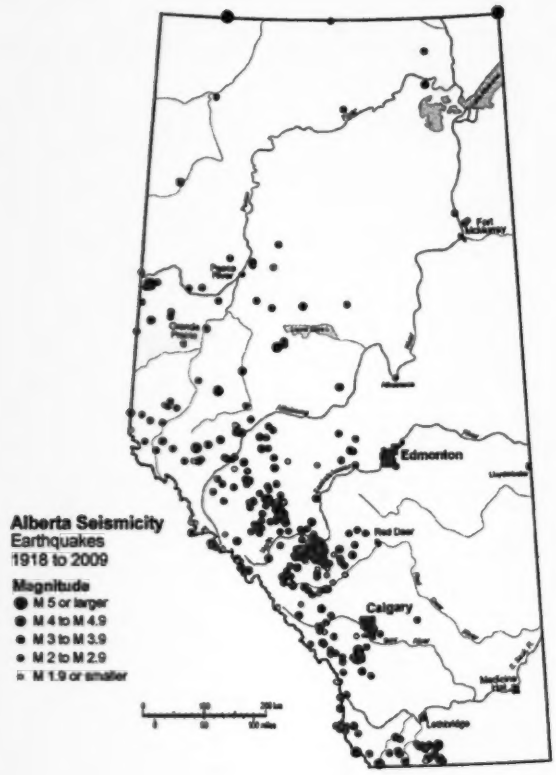
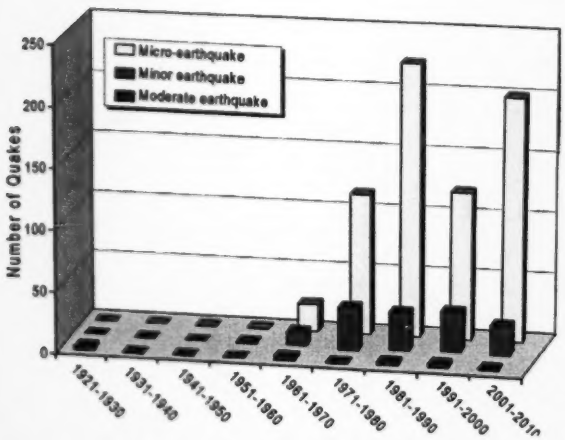


Earthquake locations recorded by Earthquakes Canada between 1918 and 2010. The magnitude 5 earthquakes on the northern border occurred in 1918 and 1922. Their locations are less certain as there were only two permanent seismographs in Canada prior to 1920: one in British Columbia and the other in Ontario. In 1920, four additional seismographs were added across the country.



Frequency chart showing the number of recorded earthquakes in Alberta by year and magnitude from 1918 to February 2010.

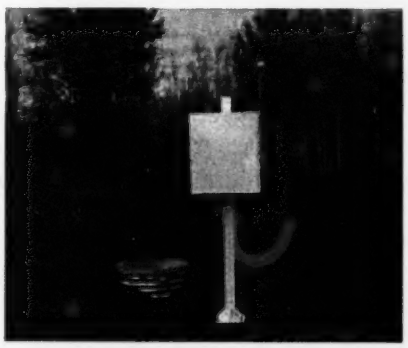
Researchers at the Geological Survey of Canada (GSC) and the University of Alberta have suggested that the increases in seismicity are not solely the result of upgrades to the seismic networks, but also connected to hydrocarbon production. A study by the GSC, in the Fort St. John region of B.C., linked the local increase in seismicity with the location and timing of oil production. Similar studies near Rocky Mountain House, although compelling, were not as conclusive. The Rocky Mountain House studies implied, but did not prove, a connection between seismicity beneath the Strachan reservoir and gas production.

How is an Earthquake Detected?

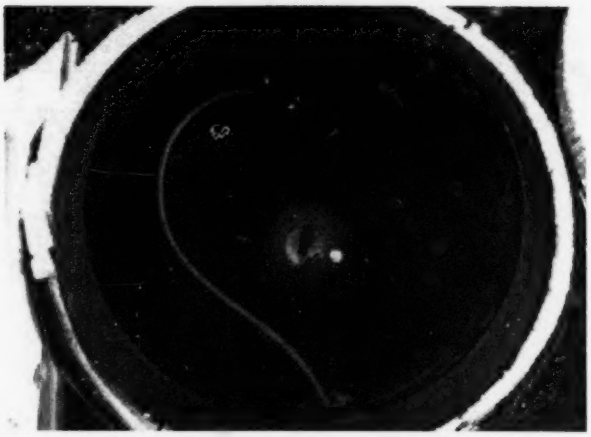
Seismometers record seismic waves from earthquakes. Their signals are digitally recorded and sent by telemetry (sent by Internet or satellite in a continuous data stream) to seismologists at processing agencies, such as the GSC or the United States Geological Survey. Encoded in the data are several key pieces of information: the wavefront arrival time, the first motion of ground displacement (up or down, called polarity), the displacement amplitude and the displacement duration.

An earthquake's magnitude is calculated from the amplitude and duration of the recorded waveform. The origin time and location (latitude, longitude and depth) are calculated from the arrival times of seismic waves at three or more seismic stations. A computer program, with information about the seismic stations and the local or regional Earth velocity structure, calculates the location in an iterative process.

Accurate locations require many seismic stations and a good spatial distribution of the stations. Large earthquakes have more energy, and their signals are picked up by both local and distant stations. Whereas less than magnitude 2 earthquakes are picked up by fewer stations.



Completed installation of a seismometer (cylindrical vault) and seismographic data logger (elevated box). (Photo credit: Geological Survey of Canada.)



Inside the vault of a semi-permanent seismic station. The seismometer is a bowling ball-sized object that sits on a cement pad. It measures the ground movement during an earthquake. (Photo credit: Geological Survey of Canada).

The permanent seismic stations monitored by Earthquakes Canada easily pick up minor and large earthquakes. However, micro-earthquakes can be under-reported because the local population does not feel them and because they require a closely spaced network of seismic stations to record them.

Seismic Stations in and Around Alberta

Alberta's first seismograph operated in Banff (BAN) from 1956 to 1966. Another seismograph was installed in Edmonton (EDM) in 1963, a third in Suffield (SES) operated from 1966 to 1993 and one in Waterton (WALA) in 1992.

These seismographs, together with nearby stations in B.C. (Penticton and Mica Creek), Saskatchewan, the Northwest Territories and Montana, have detected Alberta earthquakes as small as magnitude 2.5.

After 1990, the new stations were equipped with digital instruments and the older stations were upgraded to digital seismographs. Because of the distribution of the GSC's Canadian National Seismic Network (CNSN) seismic stations, they detect small earthquakes in southern Alberta better than in northern Alberta.

Recently, Alberta Geological Survey (AGS) participated in scouting and selecting sites for five new, semi-permanent seismic stations installed by Dr. David Eaton's research team from the University of Calgary. The newly installed stations of the Alberta Telemetered Seismograph Network (ATSN) are at High Level (HILA), Manning (MANA), Grande Prairie near the Wapiti River (WAPA), Medicine Hat (MEDA) and Priddis (PRDA).

Seismic stations in and around Alberta that help detect earthquakes. The Geological Survey of Canada operates the CNSN stations (red stars), the University of Calgary operates the ATSN stations (blue squares) and the University of Alberta operates the CRANE stations (green triangles).

Alberta Geological Survey summer student Waled Bin Merdhah taking a GPS reading at a potential site for the installation near Grande Prairie.

Two additional installation sites in the late spring of 2010 were selected: one south of the Northwest Territories border near Fort Smith (FSMA) and the other near Raymond, Alberta (RAYA). Three other sites are in the planning stages near Red Earth Creek (RDEA), Redwater north of Edmonton (RDWA) and north of Fort McMurray near the Saskatchewan border (CFLS). The addition of the University of Calgary's ATSN stations complements and extends the telemetered coverage of the CNSN stations. This coverage will record earthquakes from a magnitude of two or greater throughout most of Alberta.

To record and detect micro-earthquakes (less than magnitude 2), a much denser network is required. The addition of the University of Alberta's Canadian Rockies and Alberta Network (CRANE), led by Dr. Jeff Gu, provides a greater density of reporting stations. However, its data are not available in near real-time, instead the digital seismic data are collected bi-annually from the seismic stations.

Conclusions

Although there appears to be no threat from major earthquakes, it is important to understand seismicity patterns in Alberta and the causes of the recent increase in micro-earthquake activity. By collaborating with researchers at the universities of Alberta and Calgary, AGS will create a database of Alberta earthquakes and obtain data previously unavailable. A comprehensive database is a desirable resource for government and academic research. It will provide statistics for earthquake-hazard studies and data for investigations into the nature of seismicity and microseismicity in Alberta.

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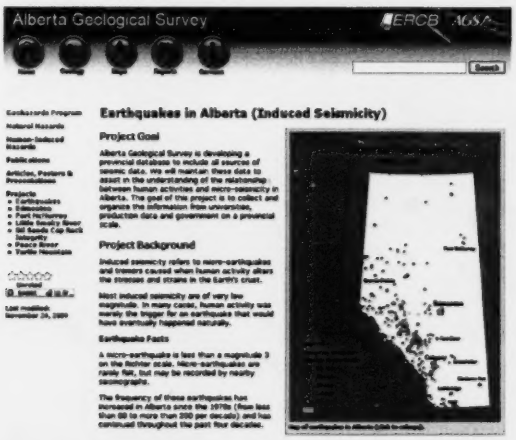

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INF 137 Metallic Mineral and Diamond Potential of Alberta Summary. 59.37 MB PDF.

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The Story of *Albertosaurus*

In recent editions of Rock Chips, we described the lives and careers of geologists who contributed to the understanding of Alberta's geology. The previous issue focused on the life of Joseph Burr Tyrrell. He discovered the extensive 'dinosaur graveyard' in the Badlands of Alberta. One of the dinosaurs discovered there was *Albertosaurus*. In this edition of Rock Chips, we will focus on the history of this dinosaur.

In many ways, the story of *Albertosaurus* is one of survival and begins after the largest mass extinction in Earth's history. This occurred at the end of the Permian – about 250 million years ago. At this time, nearly 75 per cent of the amphibian and reptile families died. One of the surviving subclasses of reptiles was the Diapsida. Modern day descendants of this subclass include crocodiles, lizards, snakes and birds.

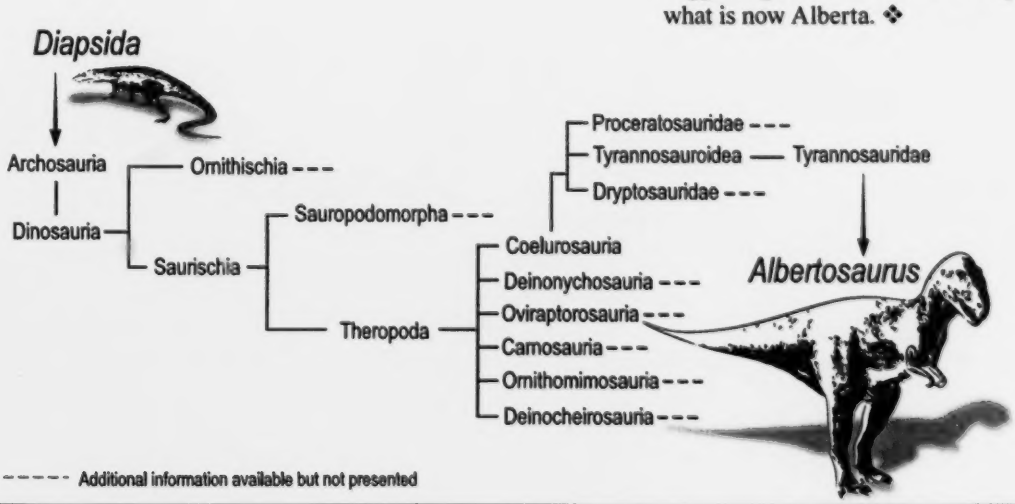
Early reptiles in this subclass had the advantage of little competition, allowing them to reproduce and migrate. As they adapted to new conditions and environments, they evolved. After another extinction occurred about 200 million years ago, only five groups of animals survived that evolved from the original Diapsids:

1. Dinosauria (dinosaurs and birds);
2. Crocodylomorpha (crocodiles);
3. Lepidosauria (lizard and snakes);
4. Pterosauria (extinct flying reptiles); and
5. Ichthyosauria (extinct, giant marine reptiles).

Albertosaurus is a member of the Dinosauria superorder. Dinosauria are divided according to the resemblance of their hips to modern lizards (order Saurischia), or modern birds (order Ornithischia). *Albertosaurus* is a Saurischian. The Saurischians have two suborders: Theropoda (walked on two legs, primarily carnivorous) and Sauropodomorpha (walked on four legs, herbivorous). *Albertosaurus* is a Theropod. As we progress along *Albertosaurus*' family tree, we find that it is a genus within the Tyrannosauridae family, the same family as *Tyrannosaurus rex*. The figure displays the relationship between *Albertosaurus* and its Diapsid ancestor.

Fossils show *Albertosaurus* had long jaws with more than 60 teeth in some cases. It had a maximum length of about 10 metres, a height of about 2 metres at the hip and a maximum mass of about 1.7 tonnes. There is speculation that it could reach speeds of between 15 to 19 kilometres per hour. Nonetheless, fossils show it was smaller than other Tyrannosaurids like the *Tyrannosaurus rex*. For comparison, the largest *Tyrannosaurus rex* found is almost 13 metres long, 4 metres tall at the hip and had a maximum mass of 6.8 tonnes.

Albertosaurus roamed what is now western North America during the Late Cretaceous. Based on fossil information, it lived between 75 and 67.5 million years ago. Researchers have found many fossil skeletons in the Horseshoe Canyon Formation in the Drumheller area of Alberta. Some researchers found similar fossils in Montana, New Mexico and Wyoming. However, there is controversy about the classification of these fossils, suggesting that *Albertosaurus* may have only lived in what is now Alberta. ❖



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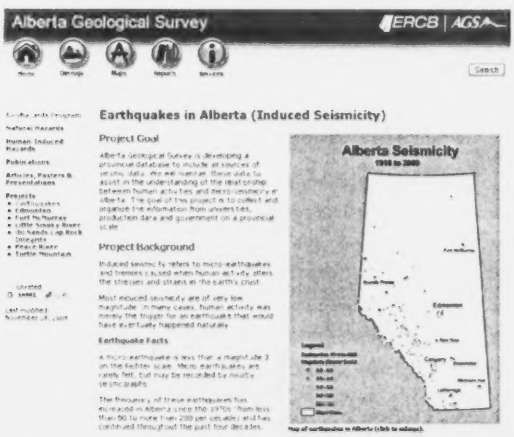

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continued on page 11

The Story of *Albertosaurus*

In recent editions of Rock Chips, we described the lives and careers of geologists who contributed to the understanding of Alberta's geology. The previous issue focused on the life of Joseph Burr Tyrrell. He discovered the extensive 'dinosaur graveyard' in the Badlands of Alberta. One of the dinosaurs discovered there was *Albertosaurus*. In this edition of Rock Chips, we will focus on the history of this dinosaur.

In many ways, the story of *Albertosaurus* is one of survival and begins after the largest mass extinction in Earth's history. This occurred at the end of the Permian – about 250 million years ago. At this time, nearly 75 per cent of the amphibian and reptile families died. One of the surviving subclasses of reptiles was the Diapsida. Modern day descendants of this subclass include crocodiles, lizards, snakes and birds.

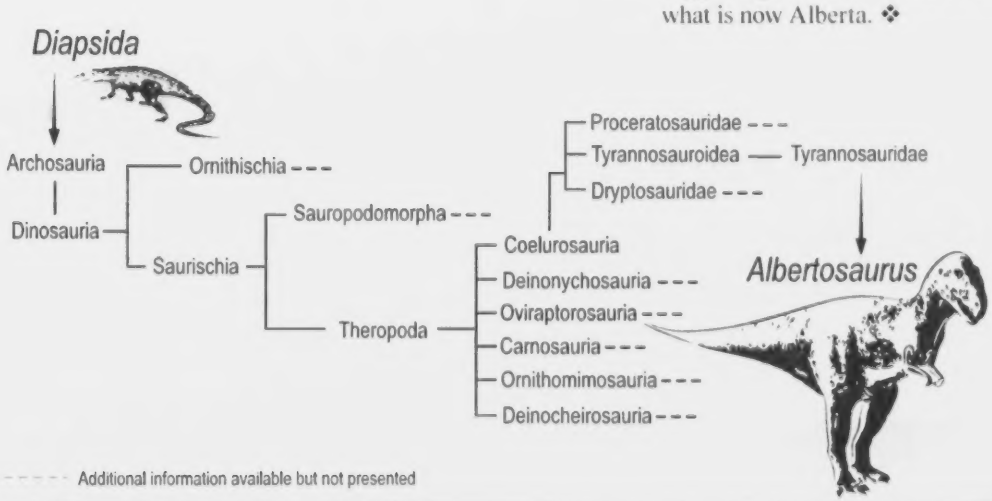
Early reptiles in this subclass had the advantage of little competition, allowing them to reproduce and migrate. As they adapted to new conditions and environments, they evolved. After another extinction occurred about 200 million years ago, only five groups of animals survived that evolved from the original Diapsids:

1. Dinosauria (dinosaurs and birds);
2. Crocodylomorpha (crocodiles);
3. Lepidosauria (lizard and snakes);
4. Pterosauria (extinct flying reptiles); and
5. Ichthyosauria (extinct, giant marine reptiles).

Albertosaurus is a member of the Dinosauria superorder. Dinosauria are divided according to the resemblance of their hips to modern lizards (order Saurischia), or modern birds (order Ornithischia). *Albertosaurus* is a Saurischian. The Saurischians have two suborders: Theropoda (walked on two legs, primarily carnivorous) and Sauropodomorpha (walked on four legs, herbivorous). *Albertosaurus* is a Theropod. As we progress along *Albertosaurus*' family tree, we find that it is a genus within the Tyrannosauridae family, the same family as *Tyrannosaurus rex*. The figure displays the relationship between *Albertosaurus* and its Diapsid ancestor.

Fossils show *Albertosaurus* had long jaws with more than 60 teeth in some cases. It had a maximum length of about 10 metres, a height of about 2 metres at the hip and a maximum mass of about 1.7 tonnes. There is speculation that it could reach speeds of between 15 to 19 kilometres per hour. Nonetheless, fossils show it was smaller than other Tyrannosaurids like the *Tyrannosaurus rex*. For comparison, the largest *Tyrannosaurus rex* found is almost 13 metres long, 4 metres tall at the hip and had a maximum mass of 6.8 tonnes.

Albertosaurus roamed what is now western North America during the Late Cretaceous. Based on fossil information, it lived between 75 and 67.5 million years ago. Researchers have found many fossil skeletons in the Horseshoe Canyon Formation in the Drumheller area of Alberta. Some researchers found similar fossils in Montana, New Mexico and Wyoming. However, there is controversy about the classification of these fossils, suggesting that *Albertosaurus* may have only lived in what is now Alberta. ❖



Preliminary Investigation of Potash Potential in Alberta

All major salt deposits form when a body of seawater is partly or wholly cut off from the ocean. In a restricted basin, seawater evaporates and salt forms as the evaporation cycle precipitates calcium carbonate and calcium sulphate. This is followed by sodium chloride and, lastly, polyhalite, which can include potassium-bearing compounds and minerals, such as potassium chloride (KCl), commonly known as potash.

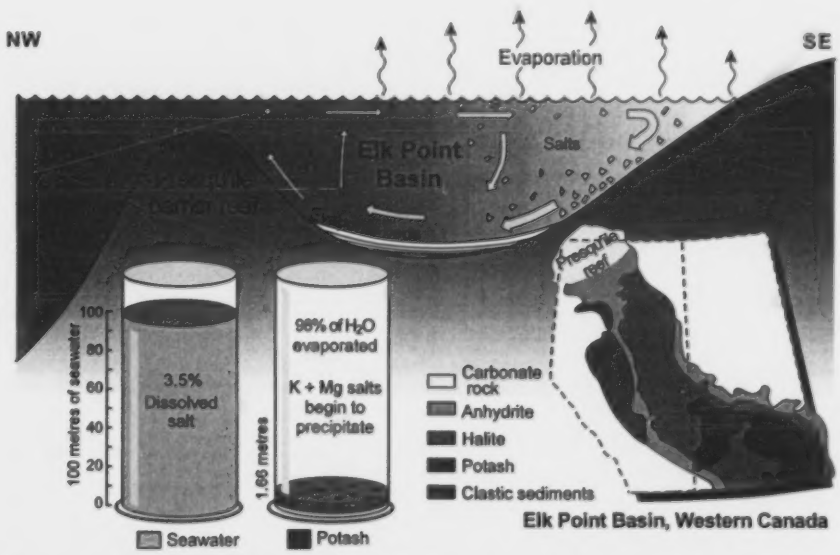
Potash is a key ingredient in fertilizers. It is essential for modern agriculture because it improves the yield, nutrient value, water retention and disease resistance of crops. Global potash markets are projected to increase due to the steady rise of the world's population and its subsequent demand for fertilizers.

In the Saskatchewan portion of the Western Canada Sedimentary Basin, some of the most extensive and richest deposits of potash in the world occur in the Middle Devonian Prairie Evaporite Formation. In contrast, there are no known economic concentrations of potash in the Prairie Evaporite Formation of eastern Alberta. This has led several authors to suggest that the basin in eastern Alberta was continually breached and replenished with normal marine water, which, in turn, disrupted excessive evaporation and large-scale precipitation of potash.

Interest in potash exploration has nevertheless spread across the Saskatchewan border into eastern Alberta. Explorers are encouraged by the results of historical 1940s drilling, mid-1960s exploration and mid-1990s government work. They are further encouraged by the knowledge that

- the extent of potash mineralization along the Saskatchewan-Alberta border and extending into Alberta is not clearly defined;
- the depositional complexity of the Prairie Evaporite Formation makes it difficult to establish salt distribution and thickness on a regional scale;
- only about 70 exploration wells have cored the Prairie Evaporite Formation in eastern Alberta, limiting our knowledge of the potash potential; and
- few geochemical data for the Prairie Evaporite Formation are publicly available.

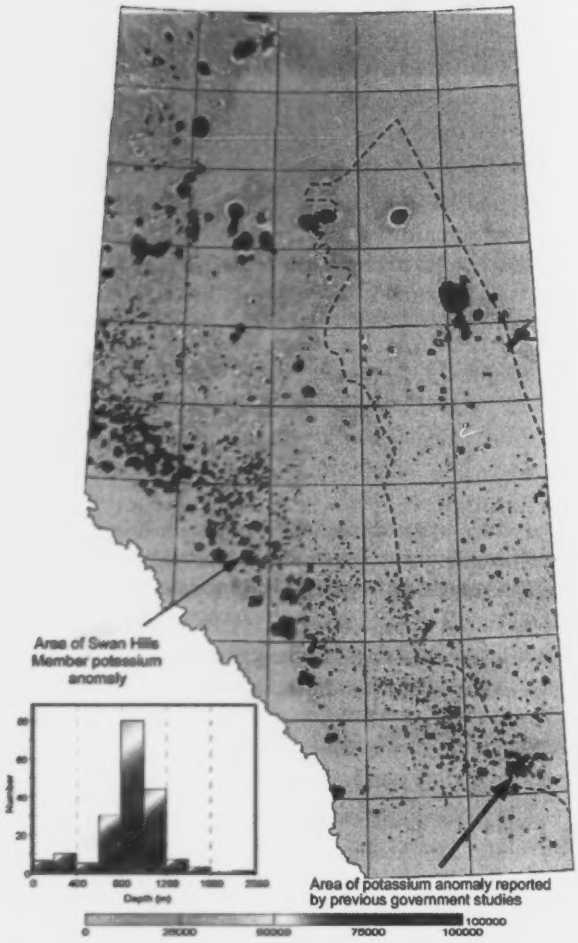
Alberta Geological Survey examined the historical exploration of potash in Alberta, together with a preliminary investigation that included contouring Alberta's groundwater and formation water datasets, and a geochemical evaluation of selected Prairie Evaporite cores.



Schematic illustrates the Elk Point Basin partly or wholly cut off from the ocean by the Presqu'ile barrier reef. It also displays the extreme ends of the evaporation cycle from seawater to potash formation.

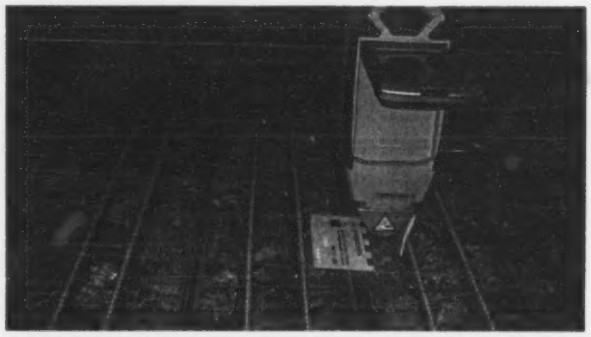
Previous government studies have shown that formation waters associated with Middle Devonian strata in southeastern Alberta, particularly those of the Beaverhill Lake Group, have elevated levels of potassium (K) up to 19 000 mg/L. These investigators thought the anomaly corresponded to potash within the underlying Prairie Evaporite salt.

Alberta Geological Survey Open File Report 2009-20 confirms the southeastern Alberta formation water potassium 'anomaly,' but also illustrates that formation waters containing greater than 10 000 mg/L of K are prevalent throughout western Alberta in areas that are not underlain by the Prairie Evaporite Formation.



Shaded contour map of culled, >10 000 mg/L of potassium water data in Alberta. Dashed polygon represents the area of Prairie Evaporite with halite >40%. Inset diagram represents a histogram of the depth (m) of the groundwater and formation water data used in the shaded contour map.

The most significant concentration of high-potassium waters in Alberta occurs in the Swan Hills Member of the Beaverhill Lake Group, which represents early Beaverhill Lake reef growth in the Swan Hills area of west-central Alberta. Five analyses from wells PC Erith 06-31-47-17W5 and PC Hanlan 11-08-47-17W5 recorded maximum values of K between 62 000 and 110 000 mg/L. It is not known whether these results correspond to contamination (e.g., potassium-bearing drilling fluids), but we speculate that dissolution and migration of potassium-enriched fluids might favour Beaverhill Lake and equivalent strata west of the Prairie Evaporite Formation because these units are now structurally at a lower elevation. Regardless, this report shows that Alberta formation waters should be further evaluated to explain the origin of potassium, and its potential as a source for economic potassium extraction. From six wells, we collected more than 300 geochemical analyses on selected Prairie Evaporite Formation well cores using a Niton XL3$_t$ 900S portable x-ray fluorescence analyzer. This is a modern, nondestructive means of testing these historical cores, some of which date back to 1944. Mineralogy was interpreted from the chemistry obtained from the XRF analysis. Calcium sulphate ($CaSO_4$) and carnallite ($KCl{\cdot}MgCl_2{\cdot}6H_2O$) are the two main impurities observed. Carnallite is particularly prevalent (up to 48%) in core from the well Pectal Dina 10-32-45-1W4, drilled in the Paradise Valley area south of the community of McLaughlin. The Pectal Dina core also yielded a 35 m intersection (1049–1084 m) of greater than 20% carnallite with 1%–8% K_2O. The same Pectal Dina core intersection yielded 12%–16% magnesium chloride ($MgCl_2$). Magnesium chloride can be used as a source of magnesium, as well as in textile and paper manufacturing, dust and erosion control, highway de-icing, and as a solid-form storage medium for hydrogen.



Halite-sylvite–bearing intervals from Vermilion Consolidated Oils #15 6-12-49-6W4 were geochemically measured using a portable x-ray fluorescence analyzer.

Five of the six wells investigated in this report yielded calculated values of greater than 10% sylvite (KCl). These wells span a vast portion of southeastern Alberta from Township 20 to 50, or from Medicine Hat to Lloydminster. In addition, seven samples representing more than 9 m of continuous core from Vermilion Consolidated Oils #15 (VCO#15) 6-12-49-6W4, collared south of the town of Vermilion, yielded an average grade of 11 wt. % K_2O, and ranged up to 19 wt. % K_2O (calculated values of 29% KCl).

These results record potash grades worthy of additional exploration. They also show potential for localized zones of potash in the uppermost Prairie Evaporite Formation of eastern Alberta.

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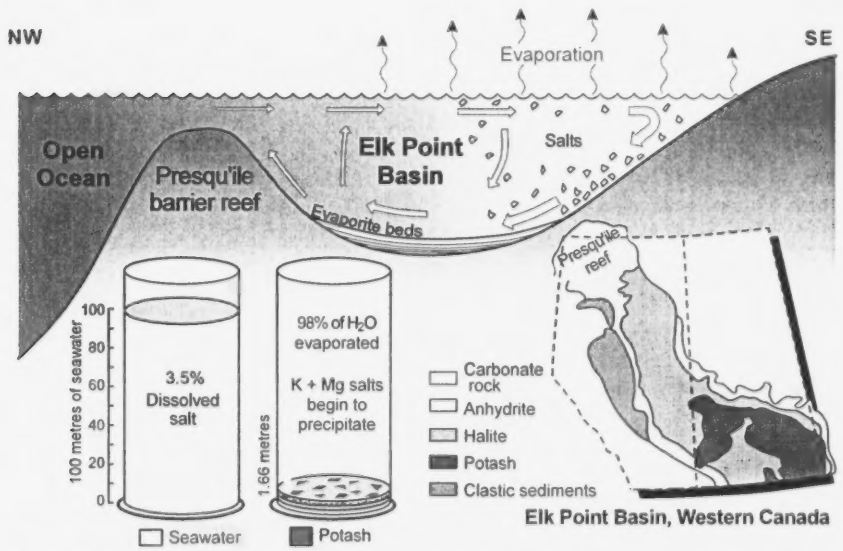

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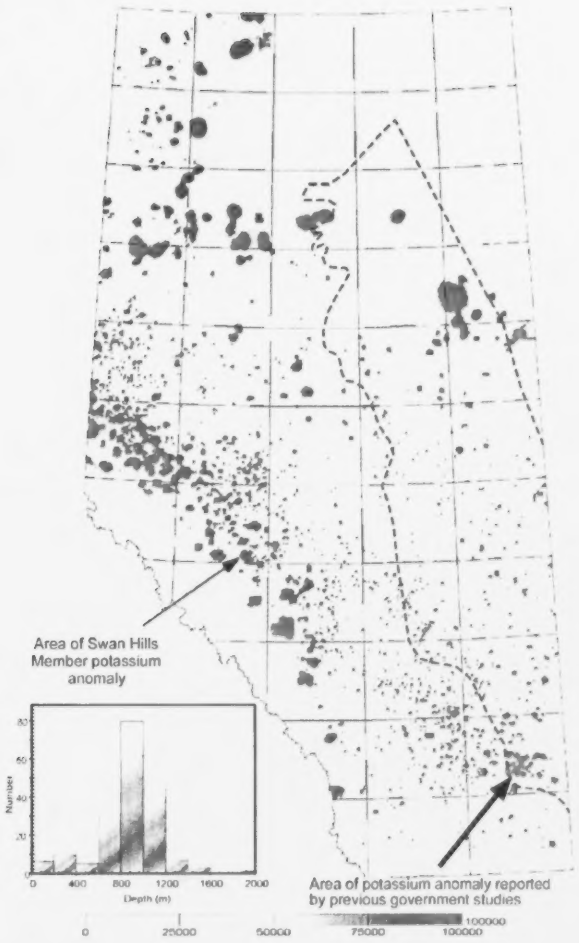
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Number
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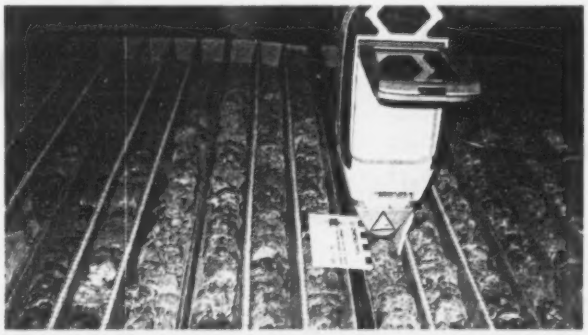

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Conferences Involving Alberta Geological Survey

GeoCanada 2010
BMO Centre, Stampede Park from May 10 to 13
ERCB Core Research Centre (3545 Research Way NW)
May 13 and 14
Calgary, Alberta

Canadian Geotechnical Society
September 12 to 15, 2010
Hyatt Regency Hotel
Calgary, AB

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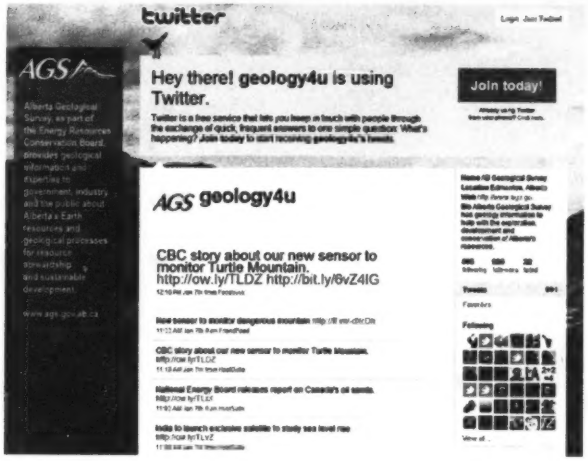

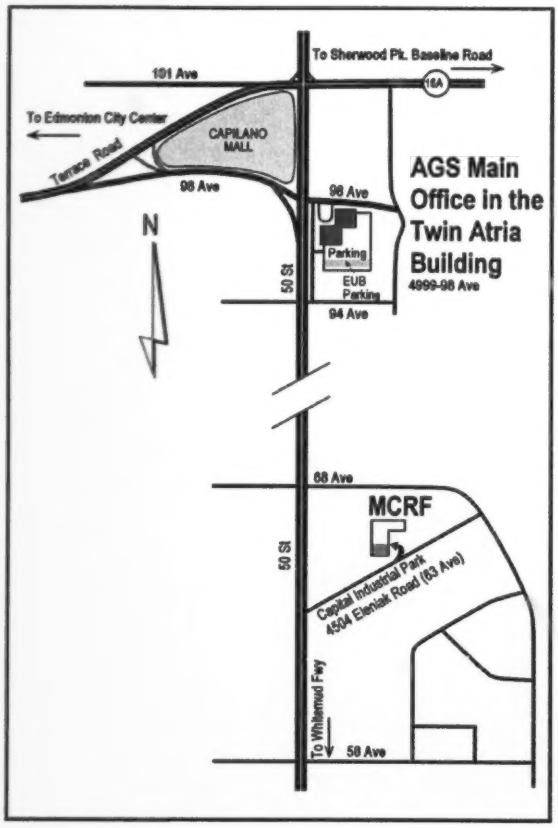

AGS Locations

Alberta Geological Survey is part of the ERCB Edmonton office.

#402, 4999 - 98th Avenue
Edmonton, Alberta
Canada T6B 2X3
Tel: (780) 422-1927
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Mineral Core Research Facility (MCRF)
4504 Eleniak Road
Edmonton, Alberta

For information on the MCRF or to book a visit, contact Rob Natyshen at (780) 466-1779 or Rob.Natyshen@ercb.ca

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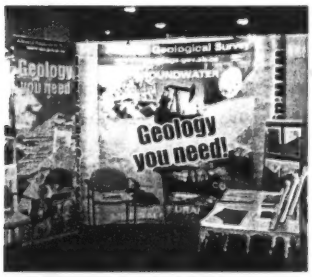

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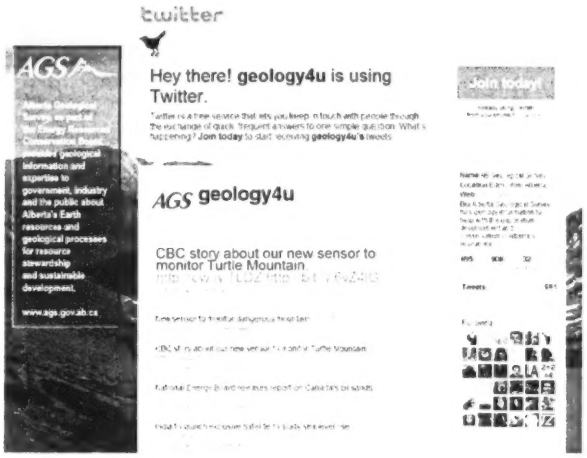

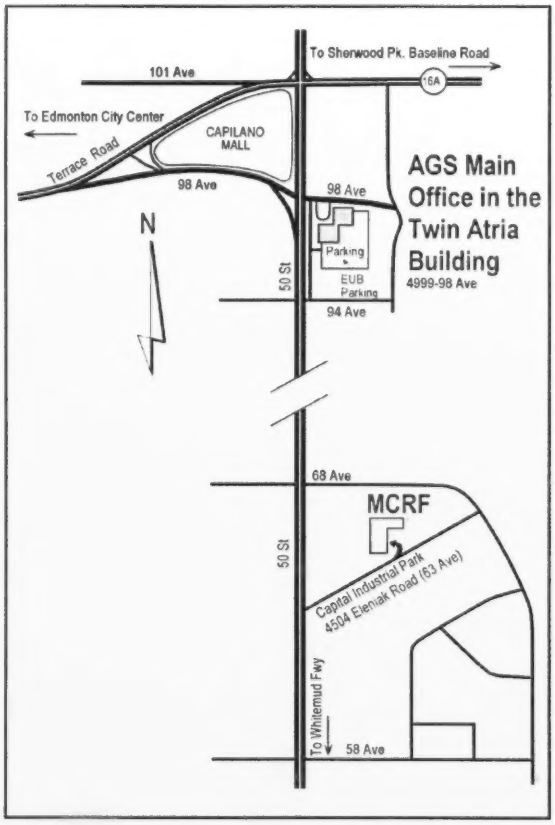

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